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(TICK FEVER.)

PROGRESS REPORT ON THE REPRODUCTIVE FORMS OF THE MICRO-ORGANISM OF TICK FEVER, WITH SOME OBSERVATIONS ON THE RELATIONSHIPS AND NOMENCLATURE OF THAT DISEASE. (16TH DECEMBER, 1897.)

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ON THE REPRODUCTIVE FORMS OF THE MICRO-ORGANISM OF TICK FEVER.

THE disease amongst cattle called, in Queensland, Tick Fever, has been shown to be, beyond question, identical with that which has long been known in the United States as Texas or Southern Cattle Fever.* The same disease is, almost certainly, prevalent, under different names,† in various other parts of the world, notably the Argentine Republic, South Africa, Roumania, and, perhaps, Java. Its geographical distribution is therefore very extensive, and its economic importance to the chief cattle-raising countries of the world by no means inconsiderable.

From the standpoint of comparative pathology, moreover, the disease is of great interest and importance, because, as will be presently further indicated, it has many points of suggestive analogy with one of the most widely prevalent kinds of malady that affect mankind—viz., malarial diseases.

It is not here proposed to give any detailed account of tick or Texas fever, because this has already been done in a very complete and masterly way by Dr. Theobald Smith and F. Kilborne,‡ whose work has, moreover, been repeatedly verified both in the States§ and in Queensland.‖ In order, however, to make clear the bearing of the observations which it is the purpose of this paper to record, it may be convenient to here briefly outline some of the more salient features and already ascertained facts in connection with the micro-organism of tick fever.

Theobald Smith, in 1889, discovered¶ that the remarkable bovine disease, whose nature had baffled all previous observers,** was due to a blood-destroying microparasite belonging to the *Protozoa*, which he named, from its physical characteristics, *Pyrosoma bigeminum*. He, in conjunction with F. Kilborne, also determined the fact that the cattle tick (*Ixodes Bovis*) was the agent by which, in Nature, the disease is communicated.††

The micro-organism in question invades the blood corpuscles,‡‡ and is also to be found free in the serum.§§ In the former situation it is very frequently, as its name implies, more or less pear-shaped, and paired.‡‡ When free it is

* Report on Texas or Southern Cattle Fever, by Theobald Smith and F. Kilborne; Eighth and Ninth Reports of Bureau of Animal Industry, U.S. Dept. of Agriculture, 1891-92.
† For synonyms *see* note on page 220 of this Report.
‡ *Loc. cit.*
§ *Vide* Bulletin 37 of Missouri Experiment Station.
‖ Report on Tick Fever, Queensland Government Printing Office, 1896.
¶ Preliminary Observations on the Micro-organism of Texas Fever, by Theobald Smith, M.D. (*Medical News*, 21st December, 1889).
** Previous American literature of the subject, *passim*.
†† *Loc cit.*
‡‡ *Vide* Fig. II.
§§ *Vide* Fig. I.

generally single,* and sometimes flagellated.* Whether encysted or free it has usually, when single, a very decided amœboid kind of movement—vigorous in free bodies, and more languid in the case of those within the cells. The number of organisms in any one blood corpuscle varies from a single body, or a single pair of bodies (which is the most common arrangement) up to six, and, possibly in some instances, even more. It is comparatively rare, however, to find more than four bodies in one cell. The blood of the general circulation, such as that obtained from a cutaneous incision, contains few infected corpuscles, even during the height of the fever, and such intracellular organisms as are present are, for the most part, of the single, amœboid, kind. The free amœboid bodies, however, are generally pretty abundant in blood, obtained during the height of the fever, from the cutaneous vessels: sometimes they are quite plentiful in cutaneous blood from animals that have recovered (the infectivity of whose blood is known to persist for years). More frequently in such blood they are by no means abundant, and are then, from the absence of any constant and well-defined morphological characteristic, often very difficult to identify. Both the free and the intracorpuscular forms of the parasite are much better seen in specimens obtained from internal organs: the free amœbæ in fresh preparations from the parenchyma of kidney, liver, or spleen, and the intracorpuscular forms in stained cover-glass preparations of blood expressed from the capillaries of the same organs or, preferably, from those of the heart's substance.†

It has been assumed, with much probability, that the different forms observed represent different stages or perhaps dual forms of development, and that the organism itself, like most cell parasites, belongs to the *Gregarinidæ* or *Sporozoa*. There obviously remain, however, many points in the life history of the micro-organism which still require explanation. What, for instance, is the precise relation of the free amœboid forms to the bodies within the cells? And what position do the latter occupy in the life-cycle of the organism? What is their destiny, and what, if any, their further developments? And, above all, what is the method of reproduction by which the micro-organism multiplies so rapidly in the blood of a susceptible animal—by simple fission, or by some kind of spore formation? and, if the latter, how and where are the spores produced?

Concerning this question of reproductive forms, Smith and Kilborne say:—‡"No forms which might be interpreted as reproductive stages have been recognised at any time in the many cases which have been studied. That the organism multiplies very rapidly in the blood of susceptible cattle is demonstrated by the fact that the injection of a small quantity of infected blood gives rise to the disease. How does this multiplication take place?"

In spite of this declaration of nescience, it is but fair to state that the insight of these excellent investigators went—as will be presently shown—somewhat beyond their actual observations, for they say:—§"There are two possibilities in view. Either the large pyriform body, while within the corpuscle or after it is set free, may enter the reproductive stage and produce a generation of very minute bodies akin to the motile, bright, intraglobular bodies seen in fresh blood, or there may be a free reproductive phase, distinct from the intraglobular forms, taking place in the blood. . . . Nevertheless, no distinctly reproductive phase has been seen during four years of observation of a great variety of cases."

Towards the elucidation of some of these matters the following observations, made in the course of investigations carried out for the Queensland Agricultural Department, at Hughenden, during the past year, will it is hoped, to some extent, contribute.

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* *Vide* Fig. I.

† The specimens from which the accompanying figures were drawn were obtained from the latter situation.

‡ Texas or Southern Cattle Fever. Eighth and Ninth Reports of Bureau of Animal Industry, page 224.

§ Report on Texas or Southern Cattle Fever, by Smith and Kilborne, pages 225, 226.

COLOURED PLATE

ILLUSTRATING REPRODUCTIVE FORMS OF TICK FEVER ORGANISM,

AND

DESCRIPTION OF SAME.

Fig.1.

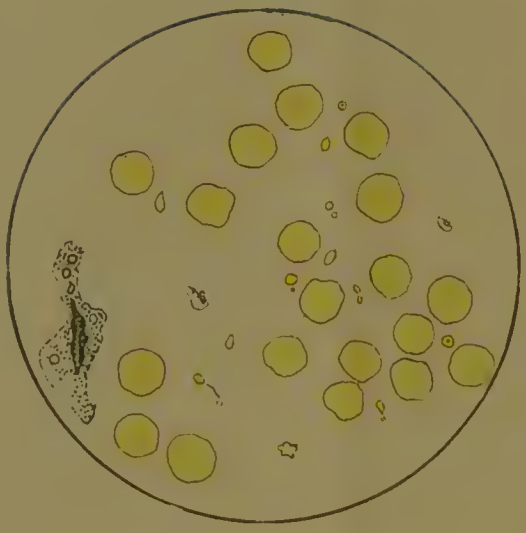


Fig.2.

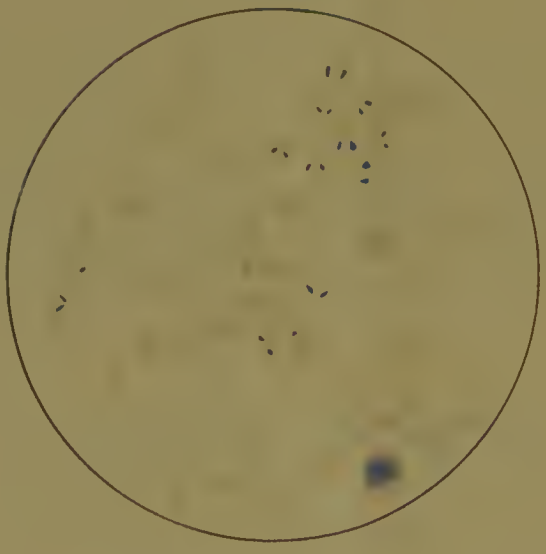
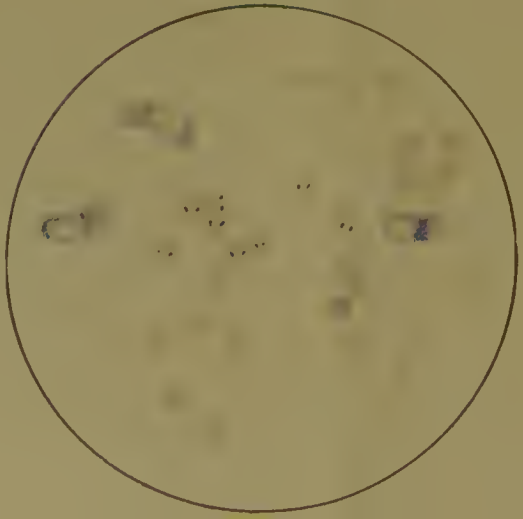


Fig.3.



In some cover-glass preparations, more particularly in such as have been made from an advanced case, a certain proportion of the *Pyrosoma* will be found to have a clear central portion which does not readily stain with aniline dyes (Fig. II.). It will also be seen that a considerable number of these bodies are now free, whilst others, not yet quite free, are still surrounded by the more or less faded and disintegrated remnants of the corpuscle in which they grew. It will also be noticed that some bodies—or rather pairs of bodies—whether free or still within the cells are a good deal larger than others, and that the clear central portion, just now referred to, is, as a rule, more marked in the larger bodies. All these appearances are perfectly obvious in almost any well-stained* blood film from the heart's capillaries of an advanced case.

On examining such preparations one now and then encounters large and very remarkable-looking bodies of more or less crescentic form. So large and so remarkable are they that it is somewhat difficult to account for their having so long escaped notice. The bodies in question are represented in Figs. III., IV., and V. It will be seen that their size varies somewhat. Their length is about three times their breadth, which latter roughly corresponds to the diameter of a bovine red blood corpuscle.

Their shape is very peculiar and characteristic, and may very well be described as crescentic, though one horn of the crescent is almost invariably thicker and more rounded than the other.† The thin end is sometimes pretty sharply incurved, giving them much the form of a farm instrument called a "bill-hook." They also very strongly resemble the spores of certain hyphomycetous fungi.‡ Sometimes, however, they are only slightly curved, and both ends are rounded. Most of them have a roundish well-defined space, which, in specimens stained with gentian violet, is almost unaffected by that dye (*vide* Fig. III.). This is, presumably, a nucleus (possibly, a vacuole?). Its position in the crescent varies somewhat, but it is perhaps more frequently placed towards the rounded end of the crescent. The substance of the crescent itself appears roughly granular, as will be presently further described. Examined with a high power, the pointed end has frequently the appearance of being open or in some way incomplete. In specimens stained with methyl blue and eosin the round nuclear (?) body is still untinted, and has sometimes the appearance of being more or less diffused (?) in the substance of the crescent; the latter, especially towards the sharper end, is more or less distinctly speckled with eosin-tinted points.§ (Fig. IV.)

The grouping of the crescents is as remarkable as their morphological appearance. Not infrequently they are found singly. But in many instances they are bunched together in very peculiar groups or clusters, the kind of arrangement being to some extent shown in Fig. IV.

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* Gentian violet has been found, by far the most satisfactory dye in this investigation.

† This peculiarity is worth bearing in mind in connection with the origin of these bodies.

‡ Such a fungus, bearing innumerable semi-lunar spore cases of about the same size as the crescents described, is frequently to be found as a parasite on cattle ticks, especially on the carcasses of such as for some unknown reason turn black and perish before or during the process of oviposition. Whether this fungus grows only as an accidental saprophyte on dead ticks, or whether it has any part in causing their death, as the *Saprolegnia ferax* kills the house-fly, has not been made out, but cultivations from the inside parts of such ticks yield the fungus in abundance. When a hanging drop cultivation of this fungus is kept at a suitable temperature and watched for several days under the microscope, spermatia may be seen to escape from the spore cases, and these spermatia are very frequently in pairs with their ends inclined towards each other, something after the manner of *Pyrosoma*. Its mycelial hyphæ also frequently contain very small, roundish, refractive, actively motile bodies of variable size, which very closely resemble the free amœboids of tick fever. The discovery of this fungus on ticks was made almost at the same time as that of the crescentic bodies in the blood of affected cattle, and so strong was the resemblance (*vide* Fig. VI.) that in spite the intrinsic improbability (some might even say gross absurdity !), both on biological and pathological grounds, of supposing them to be identical, that idea was not completely dispelled until quite a large number of inoculation experiments with the artificially cultivated tick fungus had clearly shown that it had no pathogenic effect when tattooed into the skin or when injected in large quantities—subcutaneously or into the veins of susceptible cattle. This fungus is only here mentioned on account of the waste of time and labour it caused, and might conceivably cause again.

§ This circumstance may, perhaps, be regarded as a small piece of corroborative evidence of the intracorpuscular origin of the crescents.

These very remarkable bodies were first observed by the writer in February of the present year 1897, in specimens obtained from the heart's substance of a cow that was killed in an advanced stage of the acute disease—possibly in the first stage of recovery.* Their nature was not at first at all clear, nor was their relation to the free amœbæ and to the intracellular organisms by any means evident. It was therefore decided, before submitting any detailed report of this observation, to seek the opinion of an authority of the very first eminence. Stained specimens were accordingly forwarded to Dr. Klein† with a request—as from an old pupil to a respected teacher—that he would give his opinion on these, to the writer, obscure points. It is hardly necessary for those who know Dr. Klein to say that his reply was full of "light and reading" as well as kindly interest and suggestion. Dr. Klein pointed out that *the crescentic bodies are full of the young Pyrosoma*—in fact, what is not nucleus is densely filled with these bodies, each young individual possessed of a vacuole (or perhaps nucleus) and a little protoplasm; that some of the crescents are so swollen up as to be on the point of bursting and giving birth to a new crop; that amongst the *Pyrosoma* some are considerably larger and darker stained, and show a clear nucleus (or vacuole ?); also that some crescents are considerably smaller than others, and not quite crescentic yet, and not having their substance differentiated into young individuals. From these facts Dr. Klein leans to the opinion that the *Pyrosoma* grows up into the crescent, and that the latter eventually forms like a cyst endogenously a host of the *Pyrosoma*.

The peculiar grouping of the crescents, before referred to, seems particularly noteworthy in connection with the corresponding grouping together of infected corpuscles as seen in cover-glass preparations from the capillaries of internal organs, and seems to suggest that the clumps of crescents have had their origin in the clumps of *Pyrosoma*-infected corpuscles.

On one occasion was discovered a crescent-shaped cluster of darkly-stained bodies (*Pyrosoma ?*) looking as if they had escaped *en masse* from the crescent envelope (*vide* Fig. III.), which latter is sometimes quite clearly to be seen (*vide* Fig. V.).

More recently some other forms which appear to be still further developments of the crescents have been observed. The specimens were obtained from a cow that was killed two days after defervescence from a pretty acute attack of tick fever. They are well represented in Fig. V., and give the impression that the crescents have grown into more or less irregular spheres, which, in many instances, have burst, scattering the spores (young *Pyrosoma*) broadcast. Intermediate stages between the crescent and sphere have been observed (*vide* Fig. V.). The large, clear nuclear body which was so conspicuous a feature in the crescent is equally apparent in the sphere, and even larger and more defined, but now appears to be placed centrally as a kind of core, round which the young *Pyrosoma* are clustered. In these more advanced stages it is also seen to have taken the gentian violet-dye to the extent that it has acquired a pale mauve tint. The ultimate destination of these nuclear bodies remains a mystery. Is it conceivable that they have some analogy with resting spores, and are the forms which, passing into the organism of the tick, there undergo some alternative form of reproductive development?

The discovery of these crescentic and spheroidal bodies, representing further (cystic) stages in the life history of Theobald Smith's *Pyrosoma*, supplies the piece wanting in his work, which failed only in showing how and where his organism was reproduced. It would seem also to bring that micro-organism into line with other members of the Gregarine class, in which a final spore-bearing cystic stage is known to be as general a characteristic as are the flagellated, amœboid, and cell-parasitic stages in the younger forms. It is not, however, intended to assert that this endogenous spore formation is necessarily the only way in which the tick fever organism multiplies, because Zoology

* These crescents were referred to as "spore case-like bodies" in a progress report submitted to the Stock Department in March, 1897.

† Dr. E. Klein, F.R.S., London.

teaches that other methods of reproduction are not infrequent in the earlier stages of similar organisms. Such other forms have not, however, so far been seen in the organism under consideration.

THE RELATIONSHIPS OF TICK FEVER.

It has already been remarked that the points of resemblance and analogy between tick fever in cattle and malarial disease in man are remarkably abundant. The bovine malady has, indeed, been described as a disease of *malarial type*.* It may be of interest, therefore, to inquire how far this idea is supported by the observations which have just been recorded, and how far it is in accordance with some modern views as to the life history and mode of spread of the malarial parasite. It will be convenient to consider—first, the points wherein the life histories of the organisms of tick fever and malaria coincide or differ; second, the clinical and pathological resemblances of the two diseases; third, the agencies by which each disease is communicated.

THE RESPECTIVE ORGANISMS.

The life history of the tick fever organism is probably something as follows:—Beginning as a free spore consisting apparently of a morsel of undifferentiated protoplasm and (sometimes) a flagellum, it somehow makes it way into a blood corpuscle where it at first appears as a single amœboid body. Then it divides into two (or more?) pear-shaped bodies (*Pyrosoma bigeminum*). Each of these eventually enlarges to form a crescent, in which spores are endogenously produced. The crescent becomes more or less spherical, and, rupturing, sets free a new crop of spores similar to those which formed the first stage of its developmental career.

The malarial organism† in the blood of an infected person also commences its career as a free spore. It somehow makes its way into a corpuscle. There it at first appears as a single amœboid body.‡ This body undergoes certain developmental changes which result in its subdivision into a number of spores, which in due course are set free to commence the life cycle anew. In other cases the intracorpuscular amœbæ, instead of at once passing into the sporulating stage, develop into crescentic§ or semilunar bodies which are probably the most constant and the most characteristic forms of the parasite as seen in human blood.‖ Under certain conditions they are seen to undergo further developments ¶—first into ellipsoids, then into spheres. From the latter are thrown out flagella processes which eventually become detached, and in this free state are believed by Dr. Patrick Manson to be the homologues of flagellated spores.** From these facts it is evident that there exists a certain rough parallelism in parts at least of the life histories of the microparasites concerned in the two diseases. This is perhaps better seen in the accompanying diagram.

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* Preliminary Observations on the Micro-organism of Texas Fever, by T. Smith, page 1.

† The varieties of the malarial organism corresponding to the various forms of the disease are not here considered. The general characters common to all forms only are referred to.

‡ The malarial amœba within the cells, unlike the corresponding form of the tick fever organism, often contains dark swarming pigment (melanin) granules. This phase of the malarial organism also grows to a larger size, and is paler and generally more actively amœboid in its movements.

§ The semilunars of Laveran are generally conceded to originate in this way. The origin, nature, and destination of these bodies are still, however, more or less controverted points.

‖ The malarial semilunars differ from the pyrosomal crescents in that they are present in the general blood stream (*e.g.*, from the finger), whilst the latter have only been found blocking the capillaries of internal organs, where, it may be incidentally remarked, they have probably much to do with the blood stasis observed in such situations.

¶ The developments in question are said by Manson to occur only in blood *after* it has been withdrawn from the human body; they are never discoverable in specimens fixed the moment the film is spread. (Goulstonian Lectures, before Royal Col. Physicians of London, 1896; Lecture I.)

** Surgeon-Major Ronald Ross found these flagella to be developed in the stomachs of mosquitoes from such crescents as they had swallowed with blood sucked from malarious patients. It is believed that they represent an alternative form of reproductive development designed for the perpetuation of the *Plasmodium* outside its human host, and would thus seem to lend colour to the suggestion, just now made, as to the possibility of some corresponding dimorphism in the reproductive phases of the *Pyrosoma* in the bullock and the tick respectively.

Description of Diagram.

Column 1.—The free amœboid stage common to *Pyrosoma* and *Plasmodium*.

Column 2.—The first intracorpuscular stage, also common to both organisms.

Column 3.—The malarial amœba grown larger, and sometimes containing pigment granules. No corresponding stage known in *Pyrosoma*, which never contains pigment granules.

Column 4.—*Pyrosoma* has become divided into two fresh individuals (*bigeminals*). *Plasmodium* shows two kinds of development: At A. (rosetto development), has become segmented into several fresh individuals; at B. (crescent development), has become much onlarged, with general distribution of pigment granules.

Column 5.—Both *Pyrosoma* and *Plasmodium* are free from containing corpuscles. The *Plasmodium* (in the rosette development) is seen to be breaking up into a number of free spores. N.B.—It is perhaps questionable if it is the rule for *Pyrosoma* to escape from the corpuscle, or to continue to develop in it; the eosin-staining particles in the crescents would seem to indicate the latter.(?)

Column 6.—Shows *Pyrosoma* grown into a nucleated crescent. *Plasmodium* has also becomo a crescent, containing central aggregation of pigment, and showing (occasionally) traces of corpuscle in which it grew. Rarely two crescents are developed in a single cell (Manson), a condition of things somewhat resembling the *bigeminal* development of *Pyrosoma*.

Column 7.—Both kinds of crescents have become spheres. The *Pyrosoma* sphere is giving birth to free spores.

Column 8.—Represents further developmonts of tho *Plasmodial* crescent-generated sphere. At C. the crescent has developed abortive intracorporeal spores or, at D., thrown out processes which, becoming detached, represent free flagellated spores (Manson).

CLINICAL AND PATHOLOGICAL RESEMBLANCES.

Malarial disease and tick fever are aliko due to the presence in the blood of a protozoan microparasite of the Gregarine class. The organism, in both cases, invades the red corpuscles, which it destroys in the course of its development. In both diseases the microparasite remains for an indefinite time in the blood of infected subjects, as shown, in the case of malaria, by microscopical observation, and the recurrence of the fever without fresh infection; and, in the case of tick fever, by the persistent infectivity of the blood when injected into susceptible cattle. It is not known whether cattle whose blood harbours the parasite are subject, like malarious patients, to recurrent attacks of fever in the absence of all reinfection from without.

Both diseases occur in acute, malignant, febrile forms, which are very fatal; and as comparatively mild and chronic apyrexial maladies. These varieties are, in each case, accompanied by corresponding modifications in the condition of the micro-organisms in the blood. The acute form (of each disease) is characterised by a great and rapid destruction of the red blood corpuscles, brought about by the direct action of the microparasites, and probably also by toxic substances elaborated by them. The chronic form of both maladies is marked by anæmia and debility. In the acute or malignant forms (of both diseases) the capillaries of internal organs are found to be stuffed with infected corpuscles, comparatively few of which are to be found in the general blood stream. The skin and tissues, both in malaria and tick fever, frequently acquire a yellowish tinge due to changed colouring matter derived from the disintegration of the corpuscles. Hæmoglobinuria is also observed from the same cause. Great engorgement of the spleen is a characteristic lesion of both maladies, and in fatal cases of each this organ is sometimes found to be quite disorganised, and reduced to a semifluid condition. The liver also is, in both, enlarged and bile-stained. Neither disease is, in nature, directly communicable from person to person or from bullock to bullock: neither is infectious or contagious in the ordinary sense. Both can, however, be transmitted by inoculating blood from diseased subjects into healthy ones of the same species.

Other points of resemblance might doubtless be found, but enough has been said to show that the clinical and pathological analogies are tolerably close. On the other hand, it would doubtless be possible to instance particulars in which essential differences exist. For example, malarial diseases are known to be more or less controlled by quinine, and perhaps other drugs, whilst the bovine malady has not, so far, been found amenable to any such remedies.

N.B.—The BLUE colouring of some of the bodies in Figures 2 and 3 is due to an error in the Lithography. The Figures should show *only* the violet colour with which the preparations were stained.

Fig. 4.

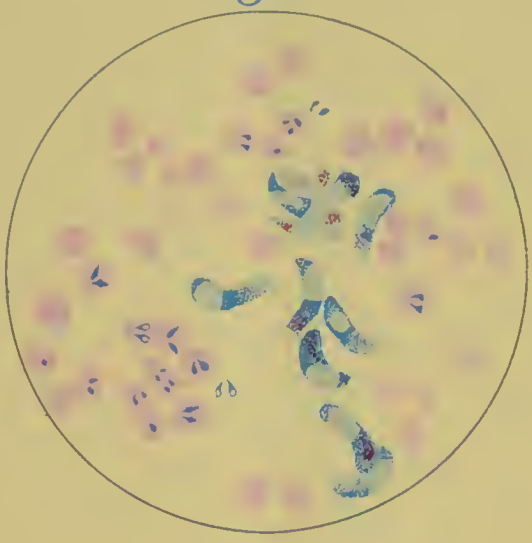


Fig. 5.

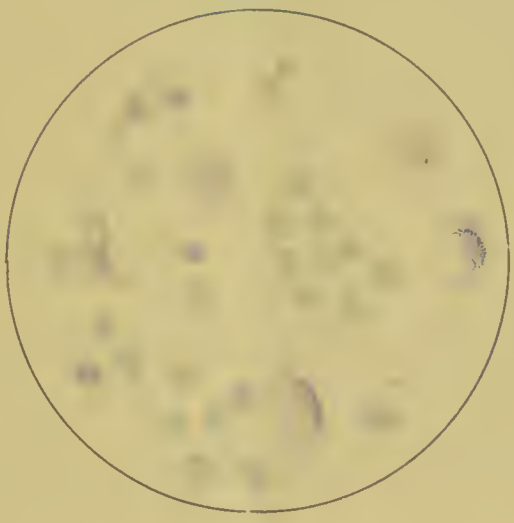


Fig. 6.

Description of Plate.

Fig. I.—Fresh specimen showing free amœboid bodies of various forms amongst the corpuscles. Leucocyte, containing refractory bodies, on the left. (× 1,000.)

Fig. II.—*Pyrosoma bigeminum* chiefly in the corpuscles, and some free; towards lower part of Fig. deeply stained round leucocyte.

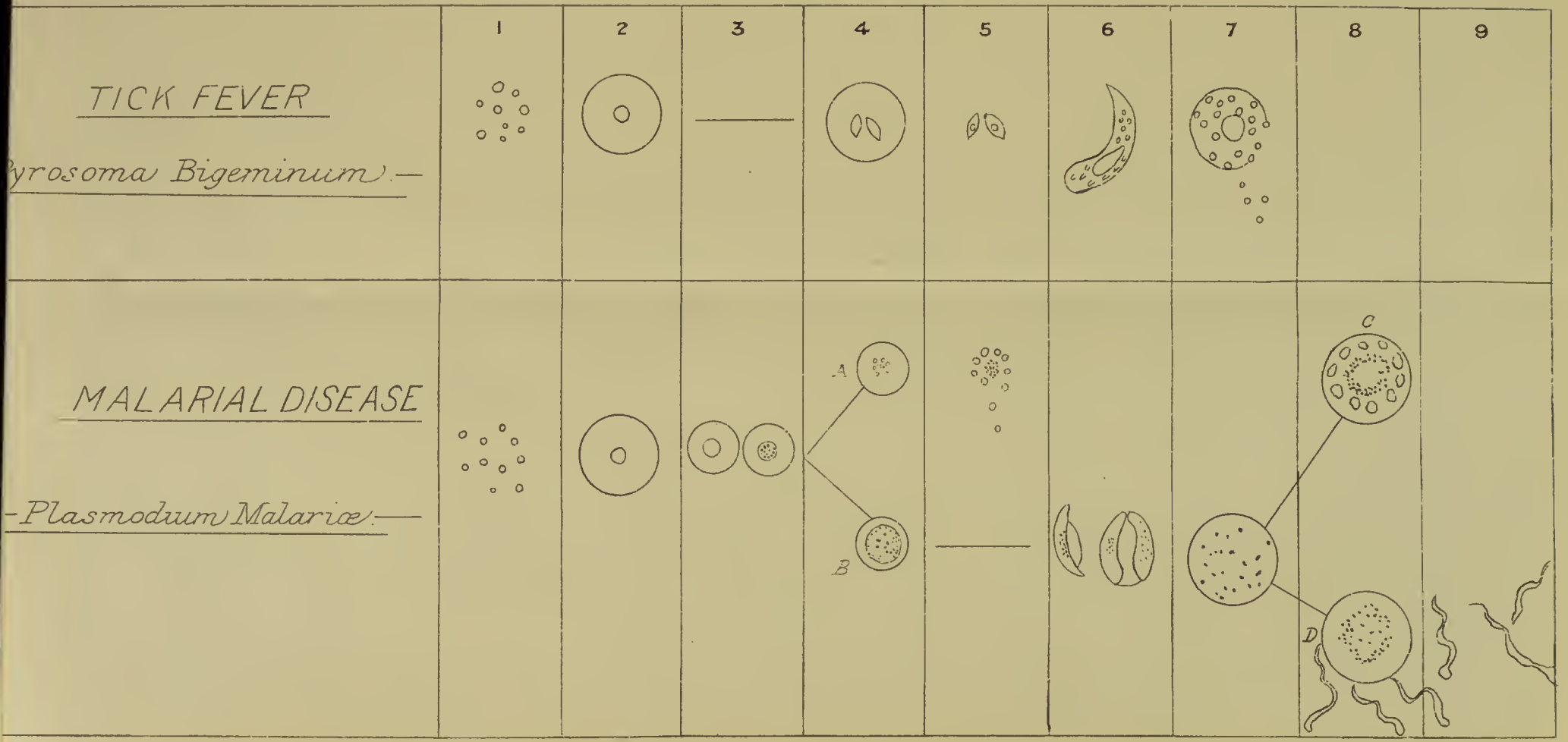
Fig. III.—Crescentic bodies with large nucleus (?); also some infected corpuscles. Towards the right is a cluster of *Pyrosoma* in the form of a crescent. (Stained with gentian violet, × 1,000.)

Fig. IV.—Shows grouping of crescents, and deep eosin coloured points; also, some corpuscles infected with *Pyrosoma*. (Stained with methyl blue and eosin, × 1,000.)

Fig. V.—Crescents further developed; some, still whole, containing young *Pyrosoma;* others rupturing and liberating those bodies; others, grown more or less epheroidal, appear to have lost the crescent envelope, and to consist only of the nucleus, round which some young *Pyrosoma* are still clustered. (Stained with gentian violet, × 1,000.)

Fig. VI.—To illustrate a case of mistaken identity. These bodies have nothing whatever to do with tick fever. They are spore cases of hyphomycetous fungus found growing on dead ticks. Spermatia may be seen to have been thrown out by some of them. (Unstained, × 1,000.)

DIAGRAMATIC REPRESENTATION OF LIFE HISTORIES
of
TICK FEVER
and Malarial Organisms



A Sporulating body

C } Vicarious forms of

Again, in the all-important matter of acquired immunity, we know that old residents of malarious places are less liable than new-comers to fall victims to the malignant forms of malarial fever, but that nevertheless the protection conferred by one attack of fever is but slight and evanescent.* In the case of the bovine disease, on the other hand, there is some good evidence to show that a very considerable protection†—if not absolute immunity—follows an attack of the acute fever.‡

METHODS OF COMMUNICATION.

A certain rough parallelism has been seen to exist in the life histories of the tick fever and malarial organisms; also some striking resemblances in the clinical and pathological aspects in the diseases they respectively produce. There would appear to be some equally striking analogies in the means by which each disease is spread or communicated.

The Cattle Tick and Tick Fever.—It has been already stated that the cattle tick is the agent by which tick or Texas fever is communicated. This fact has been definitely established by a number of carefully conducted experiments carried on both in America and Queensland.§ It has been proved and re-proved; it has been tested and re-tested; and always again and again confirmed; so that there is no room for doubt in the matter. The experimental evidence, to anyone who will be at the pains to examine it, is perfectly conclusive.‖

The micro-organism evidently lives and multiplies as a true parasite in the blood of the bullock. Its precise relation to the tick is not so clear; nor for our present purpose need it be discussed. All we are concerned, in the present connection, to know is that the tick is the means by which the micro-organism finds its way into the bullock, and is probably also the means by which—in some as yet unknown shape or form—it eventually gets out again.¶

The Mosquito and Malarial Disease.—The researches of Dr. Patrick Manson and Surgeon-Major Ronald Ross seem to indicate very strongly that the mosquito is the agent by which the liberation of the malarial *Plasmodium* from its human host is effected; also, that this insect is very closely associated with the life history of the *Plasmodium* outside the human body, and is probably the means by which the malarial germs are disseminated in external nature, and become widely distributed in earth, water, and air, and is thus, *indirectly*, the means by which the disease is spread.**

Following as a commentary on the publication of Dr. Manson's views, there appeared a long and interesting article by Dr. Amico Bignami.†† This eminent authority inclines rather to the view that the malarial organism is

* This fact has been explained on the supposition that such antitoxins as are produced in the human body in response to the malarial toxins (?) are quickly eliminated. "Acquired Immunity," by Dr. G. Archibald Reid. *Lancet*, 11th September, 1897.

† Inoculation for Tick Fever: Its Prospects and Problems. *Queensland Agricultural Journal*, Nov., 1897.

‡ No instance of a second attack produced by the injection of virulent blood has, so far, been recorded. Many such injections have been made by the writer into recovered cattle without obvious result.

§ Eighth and Ninth Reports of Bureau of Animal Industry, U.S. Dept. of Agriculture. Thirty-seventh Bulletin of Missouri Experiment Station. Report on Tick Fever by Queensland Commissioners, 1896. Queensland periodical literature, *passim*.

‖ It is necessary to emphasise this fact because there are those, both in Queensland and America, who deny it. These persons are not always the most reticent in the community, and are unfortunately, as a rule, little influenced in their judgments by experimental evidence—or, indeed, by evidence of any kind. Even the striking object lesson of ticks and disease marching hand in hand into Queensland is lost upon them.

¶ Manson, speaking of the malarial organism (Goulstonian Lecture, No. I., 1896), says: "The individual *Plasmodium* gets into man designedly, and, this being so, we may be quite sure that just as provision is made in its economy for a passage into the human body, so provision is made in its economy for a passage out of the human body. Such a provision is absolutely necessary for all true parasites; otherwise, were this not the case, the extinction of the parasite, not merely as an individual, but as a species, would be inevitable on the occurrence of the death of the host." Precisely the same argument, of course, applies to the organism of tick fever.

** Goulstonian Lecture, No. II. *Lancet*, 21st March, 1896.

†† Hypotheses as to the Life History of the Malarial Parasite outside the Human Body. By Dr. Amico Bignami. (Translated from the Italian by Dr. Sandison Brock, of Rome.) *Lancet*, 14th and 21st November, 1896.

directly inoculated into man by the mosquito, an idea in support of which he adduces the analogous case of Texas fever in cattle being directly inoculated by ticks. Bignami's remarks are so extremely *apropos* of the subject we are now considering, that it will be well to quote his own words. He says:—

"As regards malarious infection the idea that insects, and especially mosquitoes, have an intimate relation with the mechanism through which man takes the fever has been started by many observers, particularly by some of the Americans. Laveran, who, as is well known, is the principal supporter of the water-conduction theory, notes the abundance of mosquitoes in marshy places, calling attention to the fact that the drainage of the soil, whilst it suppresses the fever, also suppresses the mosquitoes. He also calls attention to the possibility (without excluding it) that mosquitoes have a part in the pathogenesis of malaria as they have in that of filariasis, and, as believed by Findlay and others, also in the dissemination of yellow fever. Grassi and Feletti exclude this possibility without even considering it, because places exist infested with mosquitoes where one does not take the fever. The fact is known to all, but it is not sufficient to exclude the hypothesis that mosquitoes are the carriers of the infection. It would further be necessary to demonstrate that in the soil or in the waters of those places there exist malarial germs, of which these insects are only the vehicles and inoculators into man.* Besides this they recall a fact asserted by Calandruccio, that in the intestine of mosquitoes malarial parasites die without developing further. (A similar fact has also been observed in leeches.) But the observation of Calandruccio can be fairly opposed to those of Ross and the hypothesis of Manson, whilst, if I am not mistaken, it has no value against the hypothesis that man is inoculated with malaria by the mosquito. On the other hand, the knowledge, if it could be well authenticated, that there exist places in which malaria can be contracted notwithstanding the absolute absence of mosquitoes and of insects which could inoculate it, would suffice to exclude the hypothesis. But one has no authenticated information of such an occurrence. On the contrary, all authors speak of the abundance of these diptera in the malarial districts. Kelsch and Kiener, in their well-known treatise, do not even allude to the possibility of inoculation. They also exclude the water-conduction hypothesis. That the infection comes by inhalation through the lungs they have no doubt.

"Notwithstanding the authority of the observers cited, it has for a long time appeared, and still appears, to me that an attentive examination of the question which I have mooted above will not be wholly useless. If one admits the inoculation hypothesis, many facts which are difficult to explain by the theory of air conduction would find a simple and satisfactory explanation, and it is easy to demonstrate this. First of all, the fact, which we have already discussed at length, that malaria is not carried by the winds would be easily understood, knowing as we do how closely these diptera are bound to the soil on which they are hatched, and how averse they are to allow themselves to be carried away, hiding when the wind blows, in the ground, amongst the grass, or under the trees; also, when a sea breeze blows in the afternoon the mosquitoes of the Roman Campagna do not show themselves, and only when the wind has gone down at the setting of the sun do they rise in clouds everywhere and attack animals and men. That the evening and night hours are the most dangerous, on account of the facility with which fever is then taken, would be easily understood by anyone who knows the habits of this nocturnal dipter. That malaria only rises to a moderate height would also be equally intelligible, because the inoculating insect always flies near the ground. A satisfactory explanation would also be furnished of the great danger of sleeping in malarial districts, a fact of which the supporters of the air-conduction theory have never been able to give more than an artificial explanation.

* The same facts, *mutatis mutandis*, and the same reasoning apply to the well-known circumstance that ticks may be present in a locality without producing—at any rate, obvious—disease.

Anyone who has experience of malarious districts well knows a number of cases in which the patient attributes the fever that torments him solely to having slept a few hours in a place where several times he had perhaps remained while awake without harm. Three years ago I made, with my colleague, Dionisi, various excursions into malarious localities for the purpose of study, and more especially with the object of collecting from the inhabitants the results of their experience—an experience which one finds with difficulty in books. Many precautions which they take against the fever are taken, one would say, to defend them from the sting of insects. They avoid going out at night; they are very careful not to sleep in the open air; they hermetically close the windows—windows with badly fitting shutters, which might impede the ingress of insects, but certainly not of air and of the germs which it might contain. They take great care of their mosquito-curtain, making it of very close net, under which they sleep, thoroughly shut in, notwithstanding the great heat.

"It is interesting to remember that Emin Pasha never omitted to take a mosquito-net with him on his African journeys, and he attributed to this precaution his not having had fever, the malarial agent in his idea being a corpuscular substance of which he supposed the close net did not permit the passage. Nicolas, in his book on the Hygiene of Camps in Marshy Places, thus expresses himself on this question: 'And the mosquito-net, well shut, is indispensable at night. Without attributing to the puncture of mosquitoes any relation whatever with the microbes of the fever, one may be certain that irritation by them produces sleeplessness and predisposes to the fever.' On the estates and farms visited by us in the Campagna, the overseers, who are less frequently attacked by the fever than the workmen, protect themselves with great care from the bites of insects, especially during sleep. On the estate of Porto, near Finmicino, where a bad type of malaria prevails, and which I visited several times in company with my colleague, Dionisi, in the height of summer, we obtained the greatest amount of information about the habits of mosquitoes, and the results of the experience of the inhabitants on the way in which fever is caught. The greater number think that the fever is taken almost always during sleep. A very brief stay sometimes suffices—even one night. But ordinarily, even in districts very subject to malaria, a longer stay is necessary, so that the workmen who go on to the property at the beginning of July for the threshing commence to get ill as a rule eight or ten days after their arrival. On the other hand, those who go in September for the working of the ground often get ill more quickly—after only two or three days' stay. Many have observed that in autumn after the rains the mosquitoes increase, and likewise the fevers, and, as the season advances, they disappear together little by little. Thus, collecting from the inhabitants (who are really much better informed about malaria than some medical men) the results of their experience, the conviction grows upon one that, if malaria were inoculated by mosquitoes into man, all the questions which I have put in a preceding paragraph would receive an adequate answer. Malaria behaves itself with regard to man as if the malarial germs were inoculated by mosquitoes."

Bignami further on says: "It is known that those do not easily catch fever who inhabit the shepherds' huts, which are made in the form of a cone, with the hearth excavated in the ground in the middle and with an aperture near the apex of the cone, so that on account of the smoke the inmates are free from insects. . . . . It is known that carefully covering the skin keeps off the fever to a certain point: the inhabitants of malarious places never omit this precaution. I have heard it related by Professor Marchiafava that a Russian medical man he knew of considered it sufficient to cover the body completely, even to the face and hands, with woollen stuffs in order to escape the fever, and was so convinced of this that he himself always went to sleep in places subject to the severer forms of malaria protected by gloves and with a kind of mask over his face; and he never took the fever."

NOMENCLATURE.

Considering the many particulars in which a resemblance or an analogy is discoverable between tick fever and malaria; considering also that the bovine malady, like the human, is of wide distribution, limited, as Smith and Kilborne point out, by latitude rather than by continents; considering, too, the confusion and inconvenience of having, for one and the same disease, a multiplicity of separate and distinct names which are, for the most part, meaningless or misleading, or have only a purely local or symptomatic significance*—one is tempted to inquire if some one general and appropriate name cannot be found. This is obviously a task for nosologists and etymologists, and would probably be easier to criticise than to accomplish.

The Queensland popular name of "tick fever," embodying as it does a distinct etiological indication, is probably the best name yet introduced. But the tick does not necessarily carry the disease,† nor is the disease necessarily a fever.‡ The relationships which have been mentioned might, perhaps, at first glance, suggest the term "bovine malaria," but that is at once negatived as implying an etiological identity which does not by any means exist. We desire to connote a true relationship without suggesting a false identity. The latter necessity excludes such words as "malaria" and "paludism," which have already another and quite well-defined meaning. We seem to need a word somewhat allied in significance to these, because—though they are both very much open to criticism on all grounds—they have the prestige of long and universal usage, and convey a very distinct pathological entity, correlation with which we desire to signify. The word "palustrism" is perhaps rather cacophonous and barbarous in construction, but it might possibly meet our requirements, since it does not appear to have been—at any rate, so extensively—employed in the sense of "malaria" and "paludism," and yet carries with it a suggestion of something the same general idea. If to such a word we added the generic term "Ixodic," to indicate the remote causative factor, we should have in the "double-barrelled" name—"ixodic palustrism"—a painful, but perhaps sufficiently descriptive, appellation.

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* The following are some of the names that have been applied to this disease:—Redwater, Texas Fever, Southern Cattle Fever, Yellow Fever, Splenic Fever, Southern Cattle Plague, Haemoglobinuric Fever, Spanish Fever, Red Murrain, Mexican Fever, &c., &c., &c.

† Many instances have been recorded where ticks have been present for many months without producing any obvious disease—which, at least, suggests that some cattle ticks do not carry the specific micro-organism.

‡ *E.g.*, in its chronic forms.

By Authority: Edmund Gregory, Government Printer, William street, Brisbane.